Appendix B
I&J Waterway PSDDA Sediment Characterization Sampling and Analysis Plan

I&J Waterway
Bellingham, Washington

Prepared by:

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RETEC Project Number: PORTB-18449-100

Prepared for:

Port of Bellingham
1801 Roeder Avenue
Bellingham, Washington 98225

July 27, 2005

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July 27, 2005

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List of Acronyms

ARI	Analytical Resources, Inc.
ASTM	American Society for Testing and Materials
BT	bioaccumulation trigger
COC	chemical of concern
DAIS	Dredged Analysis Information System
DGPS	Differential Global Positioning System
DMMP	Dredged Material Management Program
DMMU	Dredged Material Management Units
DNR	Washington State Department of Natural Resources
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
MDL	method detection limit
ML	maximum level
MLLW	mean lower low water
MS/MSD	matrix spike/matrix spike duplicate
Port	Port of Bellingham
PSDDA	Puget Sound Dredged Disposal Analysis
PSEP	Puget Sound Estuary Protocol
QA/QC	quality assurance/quality control
RI/FS	Remedial Investigation and Feasibility Study
SAP	Sampling and Analysis Plan
SL	screening level
SMARM	Sediment Management Annual Review Meeting
SMS	Sediment Management Standards
SQS	Sediment Quality Standards
SVOC	semivolatile organic compound
TDL	target detection limit
TOC	total organic carbon
USACE	U.S. Army Corps of Engineers
VCP	Voluntary Cleanup Program

1 Introduction

1.1 Project Description

This Sampling and Analysis Plan (SAP) provides the scope and methods to evaluate the suitability for open-water disposal of sediments at the I&J Waterway Site (Site) in Bellingham Bay in Bellingham, Washington under the Puget Sound Dredged Disposal Analysis Program (PSDDA) (See site map, Figure 1-1). This testing is being performed in support of the Sediments Remedial Investigation and Feasibility Study (RI/FS) occurring at the Site under the oversight of the Department of Ecology (Ecology). The need for disposal is driven by the cleanup at the site, but the design of the remedial activities will be influenced by navigation needs within the waterway and adjacent areas.

Based on areas identified for remediation in the Phase 2 Sampling (ThermoRetec, 2001), the area of the site within which dredging may occur is shown in Figure 1-2. This area has been divided into six (6) surface dredged material management units (DMMUs) and one (1) subsurface DMMU. Three (3) of the surface DMMUs and one (1) subsurface DMMU are contingent on the results of additional testing being performed as part of the RI/FS. These units may not be included in testing for open-water disposal if surface sediments do not exceed SMS criteria. The final orientation of DMMUs may change based upon results of surface sediment sampling conducted prior to coring. This SAP covers the characterization procedures for all seven DMMUs (6 surface, 1 subsurface).

These DMMUs are currently being investigated under an Agreed Order between Ecology and the Port of Bellingham to delineate sediment contamination at the site during preparation of the final RI/FS. All or some of the DMMUs will be evaluated depending on determinations from the Department of Ecology about the need for remediation in these areas based on the supplemental surface sediment chemical and biological data collected as part of a separate investigation. The SAP describing the surface testing is contained in Appendix A of the RI/FS Work Plan. Only those DMMUs in which the supplemental data from that area suggests remediation is necessary will be evaluated for open-water disposal under the PSDDA program.

An investigation of surface sediment contamination was conducted in 2000 by RETEC (formerly ThermoRetec, 2001). Elevated concentrations of bis(2-ethylhexyl)phthalate, phenol, polynuclear aromatic hydrocarbons (PAHs), and nickel are present in surface sediments. Historical sampling data collected by Hart Crowser in 1996 (1997) and Anchor Environmental (1998) indicate that mercury contamination is present in subsurface sediments. The coring prescribed in this plan will define which sediments may be unsuitable for unconfined, open-water disposal.

The total dredged volume of sediment of the three (3) non-contingent surface sediment DMMUs is approximately 9,910 cyds, including overdredge allowances. The total potential dredged material volume of all six (6) surface sediment DMMUs and the single subsurface sediment DMMU is approximately 22,030 cyds, including overdredge allowances.

1.2 Sediment Description

PSDDA guidance identifies Bellingham Bay as an area of high concern for sediment contamination. The waterway site has many known chemical sources and high concentrations of chemicals of concern (see Attachment A for historical analytical data results). Therefore, as an area of high concern, PSDDA guidance specifies that the maximum surface sediment volume represented by each surface DMMU is 4,000 cyds. Maximum subsurface sediment volume contained in each DMMU is 12,000 cyds.

Data collected as part of the Phase 2 investigation indicate that sediment in the waterway ranges from clayey silt to sand (ThermoRetec, 2001). Areas identified for remediation have been divided into 6 surface DMMUs and one subsurface DMMU based on similar contaminant levels (see Section 3 and Attachment A). Mudline elevations of sediments in the DMMUs range from approximately 0 to -17.0 feet MLLW.

RETEC proposes to characterize sediment by collecting and analyzing representative core samples in accordance with PSDDA requirements for each of the DMMUs. Dredged materials that pass chemical and biological guidelines may be disposed of at the Rosario Straits dispersive site if determined suitable, or to the Bellingham Bay non-dispersive open-water disposal site as part of the proposed project.

The field activities will be performed by The RETEC Group, Inc. (RETEC) on behalf of the Port of Bellingham (Port). Field sampling activities are currently scheduled for the summer of 2005.

1.3 Site History

The Site is located between Hilton Avenue and Bellwether Way on the Bellingham waterfront and was formerly called the "Olivine-Hilton sediment Site" (Figure 1-1). The Site includes areas of contaminated marine sediments in both the I & J Waterway and nearby berthing areas. The Waterway is located primarily on a state-owned aquatic land. The Port owns the berthing areas on the south side of the waterway and the surrounding uplands. The Waterway includes a federally authorized navigation channel with a current authorized channel depth of 18 feet below Mean Lower Low Water (MLLW). The U.S. Coast Guard owns the property north of the Site and berths vessels within the waterway and northern berth areas.

The upland areas near the Site include the former Olivine Corporation lease area and a property to its southwest that is currently leased to Bornstein Seafoods.

The ownership and history for the Site and adjacent upland properties were defined in the Phase 2 Sediment Sampling Report (ThermoRetec, 2001). The Whatcom Falls Mill Company owned and operated a lumber mill in the vicinity of the Site between the early 1900's and 1940. In 1944, these properties were acquired by the Port and leased to tenants, including Bayshore Lumber, who operated a lumber company (1947-1962) and H&H Products, who managed the same lumber mill (1963-1972) at the head of the waterway. The Olivine Corporation operated a rock crushing plant for the mineral olivine between 1963 and 1992. During that period, dust and wastewater were periodically released to the waterway. North Pacific Frozen Products managed a food processing plant between 1946 and 1959 in the location of the current Bornstein lease. Bornstein Seafoods has operated a seafood processing plant from 1959 to present in that location. Bornstein Seafoods provided diesel fuel to boats at its dock between 1960 and the early 1980s. A fire destroyed the main Bornstein Seafoods building in July of 1985. Fire suppression efforts lasted for two days, during which time fire control water was discharged directly to the Site.

Environmental impacts to the Site as documented by previous studies include contaminated surface sediments containing elevated concentrations of bis(2-ethylhexyl)phthalate. The elevated phthalate concentrations are located around the Bornstein Seafoods lease area in the vicinity of the 1985 fire. Surface sediments are also contaminated with nickel in the southeastern portion of the waterway adjacent to the former Olivine Corporation lease area. Nickel is a constituent within olivine ore. Additional contaminants present in subsurface sediments include mercury, phenols, and polynuclear aromatic hydrocarbon (PAH) compounds (ThermoRetec, 2001).

Dredging of approximately 68,000 cubic yards of sediments was conducted during maintenance dredging of the I&J Waterway by the Army Corps of Engineers in 1992 (West Central Environmental and ThermoRetec, 2000). Approximately 25,000 cyds were found to be unsuitable for unconfined, open-water disposal.

1.4 Program Objectives

The primary objective of the characterization is to collect the necessary chemical, physical, and biological testing data to evaluate the suitability of open-water disposal for site sediments that may be dredged as part of the proposed project.

The sediment characterization program objectives and constraints are summarized below:

- To characterize sediments for dredging in conformance with PSDDA requirements to enable the PSDDA agencies to designate approved disposal option(s);
- To collect, handle, and analyze representative sediment core samples that characterize the full dredging prism in accordance with protocols, timing, and QA/QC requirements outlined in the PSDDA Evaluation Procedures Technical Appendix (June 1988), the updated procedures documented in Chapter 5 and Appendix A of the PSDDA Phase II Management Plan Report (September, 1989), modifications made through the PSDDA and Sediment Management Annual Review Meeting (SMARM) process, and procedures presented in PSEP Recommended Protocols for Measuring Selected Environmental Variables in Puget Sound.
- Sediment cores will be composited and analyzed in a timely manner to meet the remediation schedule and PSDDA requirements for sample holding times, including those related to possible biological analysis, if needed.
- Chemical and biological testing results will be compared to chemical guidelines or biological performance criteria presented in the Evaluation Procedures Technical Appendix – Phase I (PSDDA, 1988), the PSDDA Management Plan Report – Phase II (PSDDA, 1989), as well as any revisions to guidelines or performance criteria that have been incorporated as part of the SMARM process.

2 Project Team and Responsibilities

The sediment characterization program will include: (1) project planning and agency coordination, (2) field sample collection, (3) laboratory preparation and analysis, (4) QA/QC management, and (5) final data reporting. Staffing and responsibilities are outlined below.

2.1 Project Planning and Coordination

Dan Berlin, RETEC, will be the overall Project Manager responsible for developing and completing the sampling program, and the primary contact for technical issues related to this SAP and the sediment characterization report. Following plan approval by the USACE, Mr. Berlin will be responsible for timely and successful completion of the project. Mr. Berlin will provide a copy of the approved SAP to all sampling and testing subcontractors, and coordinate any significant deviations from the approved sampling plan with the appropriate PSDDA agencies.

2.2 Field Sample Collection

Nick Bacher, RETEC, will provide overall direction to the field sampling and laboratory analysis programs in terms of logistics, personnel assignments, field observations, and analytical laboratory selection. Mr. Bacher will also supervise field collection of the sediment core samples. Mr. Bacher will be responsible for ensuring accurate sample positioning, recording sample locations, depths, and identification, ensuring conformance to sampling and handling requirements, including field decontamination procedures, photographing, physical evaluation, and logging of the samples, and for chain of custody of the sample cores until they are delivered to the analytical laboratory.

2.3 Laboratory Preparation and Analysis

Leslie McKee, RETEC, will be responsible for documenting sample preparation, observations, and chain of custody until the time she delivers the samples to the appropriate laboratory. Ms. McKee will also instruct the analytical laboratory on the need to maintain required handling and analytical protocols including detection limit requirements for dredge material characterization. Ms. McKee will ensure that archived sediments are stored under proper conditions. Analytical Resources, Inc. (ARI) will handle and analyze the submitted samples in accordance with PSDDA analytical testing protocols and QA/QC requirements. ARI will perform sediment grain size analysis. Vizon Scitec (Vancouver, BC) will conduct biological testing.

2.4 QA/QC Management

Jennifer Fetting will serve as Quality Assurance Representative for the sediment characterization project. She will perform quality assurance oversight for both the field sampling and laboratory programs. She will remain fully informed of field program procedures and progress during sample collection and laboratory activities during sample preparation. She will record and correct any activities that vary from the written sampling and analysis plans. She will also review the laboratory analytical and QA/QC data to ensure that data are valid and procedures meet the required analytical quality control limits. Upon completion of the sampling and analytical program she will incorporate findings into a QA/QC report.

2.5 Final Data Report

Nick Bacher will be responsible for preparation of a PSDDA Data Evaluation Report, including descriptions of sample locations and depths, sampling, handling and analytical methods, QA/QC, and compilation and interpretation of data. Dan Berlin will provide technical oversight and review of the document. The report will include the following elements:

- Type of sampling equipment used;
- Protocols and procedures used during sampling and testing and an explanation of any deviations from the sampling plan protocols;
- Descriptions and core logs of each sample, including penetration and recovery depths, compositing intervals, mudline elevation, grain size, and geologic contacts;
- Methods used to locate the sampling positions within an accuracy of ±2 m;
- Maps and tables identifying locations where the sediment samples were collected, reported in State Plane Coordinates to the nearest foot;
- A plan view of the project site showing the waterway, bathymetry, and actual sampling locations;
- Chain of custody procedures used, and explanation of any deviations from the sampling plan procedures;
- Tabular summary of chemical testing results in DAIS (Dredged Analysis Information System) format, with comparisons to USACE guideline chemistry values; and
- Final QA Report, which will identify any field and laboratory activities that deviated from the approved sampling plan and the referenced protocols. The QA Report will assess the overall validity of the collected data.

3 Sample Collection and Handling Procedures

This SAP provides details of specific data collection and analysis activities designed to support the objectives of the project. Preparation of the SAP follows the USACE guidance manual titled *Requirements for the Preparation of Sampling and Analysis Plans* (USACE, 1994), the components and strategy of which are provided in the following subsections.

3.1 Definitions

The following definitions apply to this sampling program:

- **Dredging Prism:** the entire volume of sediments to be dredged, including a 1-foot overdredge allowance.

- **Sampling Depth (Penetration Depth):** the entire cumulative depth of penetration of the coring device from the sediment/water interface.

- **Sediment Core:** the entire cumulative length of sediment extracted by the coring device. Typically, the recovered sediment length is less than the total penetration depth due to compaction during coring.

- **Core Section:** each core section is 4 feet long except where the total sediment depth leaves a core section less than 4 feet at the bottom of the dredging prism. Core sections for each sediment core are designated alphabetically, beginning with "A" for the 4-foot surface layer and proceeding downward from the top in 4-foot increments…A, B, C, etc., to the bottom core section. Core sections are composited within Dredge Material Management Units for laboratory analyses. Slightly longer or shorter core sections may be composited if stratigraphic contacts in the sediment sequence are observed during core processing. One-foot core sections will be collected from below the dredge prism for archiving (z-sample). Core sections are composited within Dredge Material Management Units for laboratory analyses.

- **Dredged Material Management Unit (DMMU):** the volume of dredged material for which a separate decision on suitability for unconfined open-water disposal can be made. DMMUs are typically represented by chemical and biological testing of a single sample and composited from one or more core sections within the DMMU.

- **Surface Sediments:** sediments located within a 4-foot-thick surface layer. Surface sediment samples are repsresented by core sections designated by the capital letter "A"

- **Subsurface Sediments:** sediments located beneath the 4 foot layer of surface sediments. Subsurface sediment samples are represented by core sections designated by the capital letters “B”, “C”, etc.

- **“Z” Samples:** sediments below the dredge prism which will be exposed by dredging and represent the surface that will remain when dredging is completed.

3.2 Number of Cores and Samples Required Based on Site Ranking

The dredge materials at the site are ranked by PSDDA classification scheme as an area of high concern for sediment contamination. High concentrations of chemicals of concern are found in site surface sediments, and acute toxicity in sediment bioassays may be present (see Attachment A). In accordance with PSDDA requirements, full sediment characterization requirements for a dredging area ranked high concern are outlined below:

- **Surface Sediments (0 to 4 feet):** One core section and one laboratory analysis for each 4,000 cubic yards.

- **Subsurface Sediments (> 4 feet):** One core section for each 4,000 cubic yards, and one laboratory analysis for each 12,000 cubic yards.

Four cores will be collected from each DMMU in order to achieve sufficient volume for full chemical, bioassay, and bioaccumulation analyses. These cores will be composited into one surface sample within each DMMU to characterize more recently deposited sediments and one composite for the subsurface DMMU. A z-sample representing the top one-foot of the new surface following dredging will be collected and archived to verify compliance with Washington State’s antidegradation policy. If the DMMP and/or the SMS programs require their analysis, testing will consist of conventional and chemistry analysis.

As shown in the historical data in Attachment A, much of the surface sediment is impacted with bis(2-ethylhexyl)phthalate, nickel, of PAHs. Mercury contamination and phenols are present in subsurface sediment and are not expected to extend beyond the depth to which the federal channel is maintained (-18 feet MLLW). Table A-1 summarizes surface chemical concentrations from studies in 1997 and 1999 and Table A-2 shows coring data from 1997 to a depth of 7.1 feet below mudline. Table A-3 provides results of the Phase 2 surface sediment sampling. Figure A-1 provides exceedances of SQS or MCUL criteria from Phase 2 and other historic surface sediment investigations.

The estimated total dredged volume of sediment in the three non-contingent DMMUs in the remediation area (DMMU-3, 5, and 6) is approximately 9,950 cyds, including overdredge allowances. Dredge cuts are meant to remove sediment to -18 feet MLLW in the federal waterway with a 2 foot overdredge depth. Volumes include slope volume, and assume a 3:1 slope from the federal channel boundary. The total potential dredged volume of sediment of the additional three (3) contingent units is approximately 12,080 cyds, including overdredge allowances. One sample will be collected from each DMMU, which will be composited from four cores in each DMMU.

3.3 Conceptual Dredging Plan, Sampling and Compositing Scheme

The SAP is developed with consideration of site-specific project and environmental factors. A key requirement is ensuring that if an individual DMMU (represented by one or more core sections) is found unsuitable for unconfined open-water disposal, then that unit can be feasibly dredged independently from surrounding clean sediments so that the contaminated material can be disposed of at an alternate approved site. The sampling program for the waterway dredging project was developed as follows:

- **Prepare Conceptual Dredging Plan.** Criteria for a dredging plan were established for this site based on the depth and similar chemical and physical characteristics of the sediments, the dredge layout plan including side slopes, appropriate dredging methods and equipment, and conventional construction practices at similar dredging projects in Puget Sound.

- **Prepare Sampling Scheme.** Basic criteria for selecting sampling locations and compositing for analysis are contained in PSDDA guidance documents relative to sediment volumes to be characterized. The approach is to delineate sediment sampling grid units as basic building blocks for identifying DMMUs capable of being dredged independently.

- **Integrate the Dredging Plan with the Sampling and Compositing Scheme.** This step consisted of using professional judgment to relate the operational aspects of dredging to the compositing scheme to ensure that specific sediment volumes, represented by sampling, and analytical results can be feasibly dredged independently from adjacent volumes. A primary consideration was to provide common lateral boundaries between the surface DMMUs as much as practicable to enable full depth dredging with each dredge setup where sampling results allow use of the same disposal site.

3.3.1 Conceptual Dredging Plan

Criteria for dredging are as follows:

- Dredge by clamshell and bottom-dump barge in open-water areas, or by backhoe with extended arm under docks with diver-guided hydraulic dredging to remove remaining sediments.

- Most practicable dredge cut widths are in the range of 50 to 90 feet.

- Full box-cutting of the dredge slopes will not be allowed along the Bornstein dock (southeastern portion of waterway) and Coast Guard dock (northwestern portion of waterway) in order to protect the piling from potential slope failure due to overcutting, i.e., the pier side slope will be excavated as close to the 1V-on-3H design slope as practicable (estimated dredge volumes assume vertical dredge cuts along the pilings). Adjusting dredge volume estimates to accommodate appropriate side slope requirements will decrease the total dredge volume of each DMMU, and will be performed prior to dredging as part of the engineering design.

- Dredged removal of the dock side slopes will be conducted by advancing the dredge cut longitudinally along the pier length. This will take advantage of increased bucket control by side swing (compared to more difficult control by raising and lowering the boom as would be required by advancing into the side slope perpendicular to the pier). Advancing parallel to the pier will also enhance operator control by creating a pattern of repetitive excavation along the slope cut in reference to the pier face.

- Underpier dredge cuts will be conducted with a backhoe with an extended arm on a barge pulling sediment from underneath the pier along gaps between piles. Due to the presence of braces preventing dredge cuts in the direction perpendicular to the first cuts, a diver-guided hydraulic dredge will remove remaining sediments. Total dredge area of sediments under the two docks is less than 900 yd^2, the majority of which will be removed by mechanical dredge.

- Remaining dredge cuts will also be oriented longitudinally along the pier, i.e., parallel to the pier face and the pier side slope cut. However, it is also practicable to orient selected dredge cuts perpendicular to the pier; however, this would require more dredge positioning to initiate the additional cuts and alignments.

- Except for the dock side slope cut (which may require successive passes), the full allowable depth of removal, based on testing results, will be accomplished as the dredge advances into the cut.

3.3.2 Sampling and Compositing Scheme

The basic approach for establishing the sampling array and compositing scheme include the following criteria:

- Design sediment grid unit borders perpendicular to the federal channel boundary consistent with the maintenance dredging requirements of the waterway such that units are composed of similar sediment quality.
- Arrange grid unit borders beyond the federal channel boundary to allow for appropriate side-slope cuts (3H:1V) along the channel boundary
- Design contingent sediment grid unit borders (DMMUs 1, 2, and 4) along the perimeter of the remediation area.
- Arrange sediment grid units to provide testing of surface sediments in both shallower and deeper water.

Sediment DMMUs have been designed based on historically similar concentrations of contaminants in surface sediments. Attachment A contains a tabular summary of surface sediment data (Tables A-1 and A-3) and subsurface data (Table A-2) and one figure summarizing sample locations and contaminant exceeding SMS criteria.

The waterway sediment surface contains a distinct footprint of bis(2-ethylhexyl)phthalate with areas of PAH and phenol contamination. Nickel is elevated in sediments on the eastern portion of the inner waterway. DMMU units have been designed to minimize the chemical heterogeneity within a single unit based on historic data. DMMUs 5 and 6 contain surface sediment that exceed MCUL concentrations, and DMMU-3 contains surface sediment with SQS or MCUL exceedances.

3.3.3 Sampling Locations

Sampling locations have been designed to capture sediment that is representative of chemical and physical makeup of each DMMU. Twenty-four (24) sediment cores will be collected at approximately 60 to 150-foot intervals, depending on the shape of the DMMU. Sampling locations are established as shown on Figure 3-1. Table 3-1 lists sediment core sampling locations, core and sample nomenclature, and estimated sediment volumes of each DMMU. Each of the four sampling locations for remediation area

DMMUs is positioned in a manner to maximize the distance between sampling locations without being too close to any borders of the DMMU. Sampling locations are spaced in order to sample both more and less contaminated areas within the DMMU.

Surface Sampling Units

The surface interval from each of four sediment cores of each DMMU will be composited together into one analytical sample and designated with an "S1" extension. Table 3-1 identifies length of sediment cores for each DMMU. Surface unit depths vary according to proximity to the waterway. Depths of surface units vary in each DMMU. Maximum depths in DMMUs 1, 2, 3, 5, and 6 do not exceed 4 feet. Maximum depth of the surface interval in DMMU-4 is 3 feet. Additional sediment will be sampled from the subsurface unit below the surface interval in DMMU-4. Cores in the waterway will be sampled to -20 feet MLLW (-18 feet MLLW plus 2 feet of overdredge depth). Cuts away from the waterway are meant to provide a final slope of 3H-on-1V.

Actual sample composite depths may vary depending on observed stratigraphy in each core. Historical maintenance dredging has shown a native clay layer present at approximately -20 feet MLLW throughout much of the waterway. If a well-defined contact between recent sediments and native sediments exist and is slightly deeper or shallower than the targeted dredge cut, then the surface sample will be sampled to the contact composed of recent sediments. Z-samples will be designated with an "S2" extension and collected from composites collected from the 1 foot layer beneath the surface intervals in DMMUs 1, 2, 3, 5, and 6.

Subsurface Sampling Units

The subsurface interval from the four cores in DMMU-4 will be composited together into one analytical sample and designated with an "S-2" extension. No other subsurface units will be characterized. Table 3-1 identifies the length of sediment core sections in the subsurface intervals. Subsurface sampling intervals range from one to three feet below the surface interval. Subsurface cuts are meant to remove sediment to the depth of -20 feet MLLW within the federal channel boundary and with a 3H-on-1V slope to the edges of the DMMU.

Actual sample composite depths may vary depending on observed stratigraphy in each core. Historical maintenance dredging has shown a native clay layer present at approximately -20 feet MLLW throughout much of the waterway. If a well-defined contact between recent sediments and native sediments exist and is slightly deeper or shallower than the targeted dredge cut, then the surface sample will be sampled to the contact composed of recent sediments. Z-samples will be designated with an "S2" extension and collected from composites collected from the 1 foot layer beneath the subsurface intervals in DMMU-4B.

Reference Samples

Sediment samples collected for sediment bioassay testing will be compared to one or two reference samples collected in the field with similar grain size and total organic carbon (TOC) characteristics. Reference samples are ambient surface samples collected from areas not likely impacted by site activities. They will be collected from Samish Bay or a similar reference site in Washington and rapid field-sieved in the field to best match grain size distributions. Reference sediment samples will be submitted for grain size analysis, as well as total solids, total volatile solids, total organic carbon, grain size, ammonia, and sulfides.

3.4 Field Sampling Schedule

The field sampling schedule is constrained by the shortest sample holding time (7 days). To safely meet the holding times for composited samples, the field samples will be composited and delivered for laboratory testing within 3 days of sampling the first core section within each composite. Sampling will generally proceed by completing each core for a DMMU before proceeding to core locations for the next DMMU. Based on a review of the limited available sediment data and expected logistic considerations, it is projected that up to 5 sediment cores can be completed per sampling day. The entire core-sampling program is expected to be completed within 5 working days.

Initiation of core sampling will be preceded by preparation of sample coring and handling equipment, acquisition of appropriate EPA-approved decontaminated sample containers from the analytical laboratories, on-site establishment of positioning references and tide gauge by the surveyor, and mobilization of the coring vessel to the site.

3.5 Field Operations and Equipment

The field crew and equipment will be mobilized from RETEC's Seattle and Bellingham Offices. The field crew will make sure all equipment is in good working order prior to collection of cores. Initiation of sediment sampling will be preceded by preparation and cleaning of sample coring and handling equipment, acquisition of decontaminated sample containers from the analytical laboratory, and establishment of sampling locations in the waterway. All field sampling and sediment handling will conform to the procedures outlined in the project Health and Safety Plan.

3.5.1 Sediment Sampling Equipment

The sampling vessel and operator to be employed for the coring program will be provided by Marine Sampling Systems of Seattle, Washington. The sampling vessel, *R/V Nancy Anne*, is an aluminum, flat-deck, 36-foot-long, and 14-foot-wide catamaran vessel with twin 120-horsepower engines. The *R/V Nancy Anne* is equipped with a 14-foot-high hydraulically-operated A-frame with boom with variable speed, 3,000-pound capacity, hydraulic winch (1 to 3 ft/s), and 270 square feet of deck space. The vessel is equipped with a pilot house, freshwater and seawater pumps; and vessel draft ranges from 18 inches forward to 42 inches aft.

Sediment cores will be collected using a vibracore. A vibracoring system collects a continuous profile of sediments below mudline. The system utilizes a high frequency vibrating coring device, which penetrates into the underlying sediments with minimal distortion. This method is ideal for collecting long, relatively undisturbed cores from a variety of sediment types. The vibratory head assembly and core barrels will be deployed from the A-frame of the *R/V Nancy Anne*. If debris is encountered, alternative sampling gear will be considered, including the mud-mole or diver operated core sampling prior to moving the location.

The field representative will log each sample on a chain of custody form, noting the location, date, and time of collection. Subsequent chain of custody forms will be used to track the submittal of specific samples to the laboratory, and will be signed by any individual handling the coolers. Coolers, in which samples are kept on ice, will be in possession of project personnel or secured at all times. A complete record of drilling and sampling operations will be maintained on the appropriate sediment sampling forms.

3.5.2 Positioning and Navigation

The objective of the positioning procedure is to accurately (±2 m) determine and record the positions of all sampling locations. This determination will be achieved by documenting the following parameters at each sampling location:

- Horizontal location in state plane coordinates and latitude/longitude (NAD 83) recorded electronically when sampler is on the bottom and cable is taut and perpendicular to the water surface;

- Vertical elevation in feet (USACE MLLW) recorded from lead-line water depth measurements and tide height; and

- Time and date.

These parameters will be measured using combinations of a Differential Global Positioning System (DGPS), local tide gauges, tide programs, acoustic and lead-line water depth instruments, and back-up methods (i.e., triangulation or taping to survey control points and/or terminal landmarks or structures).

Positioning while sampling will be performed using a DGPS, which will provide positions every second with submeter accuracy for precise positioning of sample locations. The navigation system onboard the vessel will provide the vessel pilot with a navigation display to enable piloting to sample locations and recording the exact location of the sediment core. Each day, the sampling vessel will be positioned at a land-surveyed quality control point to verify the accuracy of the DGPS system, and recorded in the field notes.

As a back up, horizontal triangulation is proposed for recording station positions. If necessary, sampling locations will be identified by measuring the horizontal distance from the actual sampling location to a known survey control point and/or permanent structure to the nearest foot using an incremental tape measure. These horizontal measurements can be translated into state plane coordinates using project base maps.

3.6 Sample Collection Techniques

Sediment samples will be collected in the following manner:

- Vessel will maneuver to the proposed sample location;
- A decontaminated core tube the length of the desired penetration depth will be secured to the vibratory assembly and deployed from the vessel;
- The cable umbilical to the vibrator assembly will be drawn taut and perpendicular, as the core rests on the bottom sediment;
- Location of the umbilical hoist will be measured and recorded by the location control personnel, depth to sediment will be measured with a survey tape attached to the head assembly;
- A 4-inch-diameter, thin-walled, aluminum tube will be vibratory-driven into the sediment using two counter-rotating vibrating heads;
- A continuous core sample will be collected to the designated coring depth or until refusal;
- The depth of core penetration will be measured and recorded;

- The vibrator will be turned off and the core barrel will be extracted from the sediment using the winch;

- While suspended from the A-frame, the assembly and core barrel will be sprayed off and then placed on the vessel deck; and

- The core sample will be evaluated at the visible ends of the core tube, the length of recovered sediment will be recorded and, if accepted, the core tube will be sectioned into 4-foot lengths.

Sample recovery will be inspected relative to the following RETEC acceptance criteria:

- Overlying water is present and the surface is intact;
- The core tube appears intact without obstruction or blocking; and
- Recovery is greater than 75 percent of drive length.

If sample acceptance criteria are not achieved, the sample will be rejected. If repeated deployments (2) within a 15.2-meter (50-foot) radius within the DMMU of the proposed location do not meet acceptance criteria, then selection of an alternate sample location will be considered within the DMMU. Prior to selection of an alternative sample location, the Dredged Material Management Office (206-764-3768) should be contacted for discussion/approval.

Once the core samples are deemed acceptable, the cutterhead will be removed and a cap will be placed over the end of the tube and secured firmly in place with duct tape. The core tube will then be removed from the sampler and the other end of the core will be capped and taped. A label identifying the core will be securely attached to the outside of the core and wrapped with transparent table to prevent loss or damage of the label. The core sections will be stored upright in an insulated core storage box filled with blue ice. The cores will be sealed tightly enough to prevent leakage or disturbance during transport.

As samples are collected, logs and field notes of all sediment samples will be maintained on field forms and in a project notebook. Field forms are contained in Attachment B. Included on the forms and in this log will be the following:

- Calculated elevation of each sediment sample;
- Date and time of sampling;
- Initials of person supervising the sampling operation;
- Weather conditions;
- Sample location number and core section identification;

- Physical description of sediment; and
- Chronological occurrence of events during sampling operations.

3.7 Sample Compositing and Subsampling

3.7.1 Extrusion

Core sections will have their sealed caps removed for extrusion. The sediment from each sample tube will be extruded onto a stainless steel tray using vibratory/pushing techniques or cutting the core longitudinally using a circular saw if push-extruding the sediment is difficult. The sample will be disturbed as little as possible when extruding. Upon extrusion, the core will be split with decontaminated stainless steel wire core splitters or spatulas.

A color photograph will be taken and the sediment description of each core sample will be recorded on the sediment-sampling log for the following parameters as appropriate and present:

- Sample recovery;
- Physical soil description in accordance with the Unified Soil Classification System (includes soil type, density/consistency of soil, color);
- Odor (e.g., hydrogen sulfide, petroleum);
- Visual stratification, structure, and texture;
- Vegetation;
- Debris (e.g. woodchips or fibers, paint chips, concrete, sand blast grit, metal debris;
- Biological activity (e.g., detritus, shells, tubes, bioturbation, live or dead organisms);
- Presence of oil sheen; and
- Any other distinguishing characteristics or features.

3.7.2 Compositing

To reduce cross-contamination due to smear, the smeared sediments found along the sidewalls of the core tube will be removed prior to compositing. Only sediment that is not touching the sidewalls or ends will be collected for chemical analysis. Samples will be composited under the direction of an experienced RETEC geologist per the compositing plan presented in Table 3-1 and in accordance with USACE guidance. For sediment composite samples, equal volumes of sediment will be removed from each core section comprising a composite.

Immediately upon extrusion of cores, a subsample volume will be collected from a selected core section for volatiles and sulfide analysis without mixing by randomly selecting a sample that has not had contact with the core lining from one core representing each composite. Tables 3-1 and 3-2 indicate the stations randomly selected for volatile and sulfide subsampling. For sulfides, 5 ml of 2N zinc acetate will be added to every 30 grams of sediment using a pipette creating a thin film across the top of sediment in the jar. Separate containers will be completely filled with sample sediment for volatiles. No headspace will be allowed to remain in either container.

Sediments representing each composite sample will be placed in a decontaminated stainless steel bowl and mixed using decontaminated stainless steel mixing spoons or paddles. The composited sediment in the stainless steel bowl will be mixed until homogenous in color and texture.

Field sample recovery will be taken into account when vertically compositing the sample material. For example, a core sample with 3 feet of penetration but only 2.5 feet of recovery (retained) will have 83 percent sample recovery. Therefore, a 2.5-foot sample interval will be reduced by 17 percent from 2.5 feet to 2.08 feet to account for compaction during driving.

3.7.3 Sample Volume

Approximately 27 liters of homogenized sample will be prepared for each composite. Table 3-3 contains sediment collection requirements for each composite sample or core. Two liters of sample are required to provide adequate volume for physical and chemical laboratory analyses. An additional 25 liters of sample will be collected and archived (refrigerated), pending chemical testing results, which will indicate if subsequent biological (5 liters) testing and/or bioaccumulation (20 liters) testing is deemed necessary to determine suitability for open-water disposal. Portions of each composite sample will be placed in appropriate containers obtained from the analytical chemistry laboratories.

Each sample container will be clearly labeled with the project name, sample/composite identification, type of analysis to be performed, date and time, and initials of person(s) preparing the sample, and referenced by entry into the log book. Samples will be stored at approximately 4 °C until withdrawn for analysis.

3.8 Equipment Decontamination Procedures

Sampling and sediment compositing equipment will be thoroughly cleaned prior to use and after each sample collection event. Sampling equipment will be decontaminated according to the following procedure:

- Initial rinse with site water to dislodge residual particles;
- Wash with brush and Alconox soap;
- Rinse with tap water;
- Rinse with methanol, nitric acid, or other cleaning solvent, if necessary; and
- Rinse with deionized water.

After cleaning, all sampling equipment not immediately used will be wrapped in foil to limit the risk of contamination. Cleaning solvents, such as hexane and/or nitric acid may be considered if heavy sheens/free product are present in the sample material. In general, core tubes will not be reused for sampling.

Hand processing work (e.g., using stainless steel spoons for extracting the sample from the split cores, mixing the samples and filling sample containers) will be conducted with disposable gloves, which will be rinsed with distilled water before and after handling each individual sample, as appropriate, to prevent sample contamination. Gloves will be disposed of between composites to prevent cross-contamination between the DMMUs.

3.9 QA/QC Samples

Additional matrix spike/matrix spike duplicate (MS/MSD) samples will be collected for laboratory QA purposes. Samples will be collected from one station with sufficient sediment volume for analysis of volatiles, SVOCs, PCBs/pesticides, metals, and tributyl tin. Section 4.1.5 contains additional information on laboratory QA procedures.

3.10 Sample Transport and Chain of Custody Procedures

Containerized sediment samples will be transported to the laboratories after compositing is completed. Specific sample shipping procedures will be as follows:

- Individual sample containers will be packed to prevent breakage and transported in a sealed ice chest or other suitable container; glass jars will be separated in the shipping container by shock-absorbent material (e.g., bubble wrap) to prevent breakage;

- Coolers will be packed with ice packs or crushed ice (sealed in plastic bags) to keep the samples at 4 °C ± 2 ºC;
- Cooler trip blanks will be included with volatile samples at a frequency of one per cooler;
- Each cooler or container containing the sediment samples for chemical analysis will be delivered to the laboratory within 24 hours of being sealed;
- The shipping containers will be clearly labeled with sufficient information (name of project, time and date container was sealed, person sealing the container, and consultant's office name and address) to enable positive identification;
- A sealed envelope containing chain of custody forms will be enclosed in a plastic bag and taped to the inside lid of the cooler; and
- Signed and dated custody seals will be placed on all coolers prior to shipping.

Upon transfer to sample possession to the analytical laboratory, the custody form will be signed by the persons transferring custody of the sample container. Upon receipt of samples at the laboratory, the shipping container seal will be broken and the receiver will record the condition of the samples. Custody forms will be used internally in the lab to track sample handling and final disposition.

3.11 Health and Safety

Prior to the initiation of any field activities, all parties with review, become familiar with, and sign off in acknowledgement of the Site-Specific Health and Safety Plan, provided under separate cover. Issues related to health and safety, including emergency plans and potentially dangerous situations, will be discussed at the start of each day of sampling, and potential corrective actions will be considered.

4 Chemical and Physical Testing

This section provides an overview of the chemical and physical testing program. Samples will be analyzed in accordance with PSDDA guidelines by an Ecology-accredited laboratory using accredited methods. Table 4-1 presents the proposed analyte list, methods, and the target detection limits (TDLs).

4.1 Chemical Analyses Protocols

Laboratory testing procedures will be conducted in accordance with the procedures specified in the PSDDA Evaluation Procedures Technical Appendix, June 1988; the PSDDA Phase II Management Plan Report, September 1989; and with the PSEP Recommended Protocols. These procedures are discussed below.

4.1.1 Chain of Custody

A chain of custody record for each set of samples will be maintained throughout all sampling activities and will accompany samples during shipment to the laboratory. Information tracked by the chain of custody records include sample identification number, date and time of sample receipt, analytical parameters required, location and conditions of storage, signature of person relinquishing and receiving custody, and final disposition of the sample.

4.1.2 Chemical Analyte List and Methods

A maximum of eight composited sediment samples will be analyzed for the full suite of PSDDA analytes listed in Table 4-1. Volatiles and sulfide subsamples will be collected from a randomly selected core section immediately upon extrusion of cores to avoid volatilization of potential contaminants and (for sulfides) to add necessary preservative. Samples will be submitted to ARI laboratory for chemical analysis.

4.1.3 Physical Analysis

Grain size distribution of sediment samples will be determined using PSDDA-specified protocol (ASTM D-422 modified). Wet sieve analysis will be used to determine the size distribution greater than the U.S. No. 230 mesh sieve (sand and gravel fraction). The silt and clay fraction will be determined by the hydrometer method. One triplicate analysis of one sample will be performed for QA purposes. Sediment samples will be submitted to ARI laboratory for physical analysis.

4.1.4 Limits of Detection

The sediment composite samples identified in Table 3-1 will be analyzed for each of the parameters listed in Table 4-1. The analytical test methods and reporting limits to be achieved by the analytical laboratory are also identified in Table 4-1. The testing laboratories are aware of the PSDDA detection limit requirements and will employ all reasonable means, including additional cleanup steps and method modifications, to reach these detection limits. Failure to reach PSDDA detection limits may result in a requirement to reanalyze or perform bioassays. All reasonable means, including additional cleanup steps and method modifications will be used to bring all limits-of-detection below PSDDA screening levels. Additionally, an aliquot (8-oz) of each sediment sample for analysis will be archived and preserved at –18 °C for additional analysis if necessary.

The following scenarios are possible and will be handled appropriately:

1) One or more chemicals-of-concern (COC) have limits of detection exceeding screening levels while all other COCs are quantitated or have limits of detection at or below the screening levels: the requirement to conduct biological testing would be triggered solely by limits of detection. In this case the chemical testing subcontractor will do everything possible to bring limits of detection down to or below the screening levels, including additional cleanup steps, re-extraction, etc. This is the only way to prevent unnecessary biological testing. If problems or questions arise, the chemical testing subcontractor will be directed to contact the Dredged Material Management Office.

2) One of more COCs have limits of detection exceeding screening levels for a lab sample, but below respective bioaccumulation triggers (BT) and maximum levels (ML), and other COCs have quantitated concentrations above screening levels: the need to do bioassays is based on the detected exceedances of SLs and the limits of detection above SL become irrelevant. No further action is necessary.

3) One or more COCs have limits of detection exceeding SL and exceeding BT or ML, and other COCs have quantitated concentrations above screening levels: the need to do bioassays is based on the detected exceedances of SLs but all other limits of detection must be brought below BTs and MLs to avoid the requirement to do bioaccumulation testing or special biological testing. As in case 1), everything possible will be done to lower the limits of detection.

4) One COC is quantitated at a level that exceeds ML by more than 100%, or more than one COC concentration exceeds ML: although there is reason to believe that the test sediment is unsuited for open-water disposal without additional chronic sublethal testing data, the standard suite of bioassay tests must be completed, and no additional testing is required by the program. However, the DMMP agencies

retain the authority to require "additional, specialized" testing of any dredged material based on "reason-to-believe" whenever the disposal of that material is subject to 404 authority.

In all cases, to avoid potential problems and leave open the option for retesting, sediments or extracts will be kept under proper storage conditions until the chemistry data is deemed acceptable by the PSDDA agencies.

4.1.5 Quality Assurance/Quality Control

The analyst will review results of the quality control samples from each sample group immediately after a sample group has been analyzed. The quality control sample results will then be evaluated to determine if control limits have been exceeded. If control limits are exceeded in the sample group, the Project QA Coordinator will be contacted immediately, and corrective action (e.g., method modifications followed by reprocessing the affected samples) will be initiated prior to processing a subsequent group of samples. A summary of the types of quality control procedures to be performed by the laboratories is presented in Table 4-2.

All samples for physical and chemical testing will be maintained at the testing laboratory in accordance with the sample holding limitations and storage temperature requirements listed in Table 3-3.

4.2 Laboratory Written Report

A written report will be prepared by the analytical laboratories documenting the activities associated with sample analyses. Because of the possibility of additional bioassay testing, to the maximum extent practicable, all chemical results will be provided within 28 days of sampling to allow a timely decision for tiered biological testing. At a minimum, the following will be included in the report:

- Results of the laboratory analyses and QA/QC results;
- Protocols used during analyses;
- Chain of custody procedures, including explanation of any deviation from those identified herein;
- Any protocol deviations from the approved sampling plan; and
- Location and availability of data.

The final report will include QA2 deliverables, surrogate recoveries where appropriate, and sample custody information. QA2 deliverables are required for submission of the data into the SEDQUAL database maintained by the

Department of Ecology. A list of QA2 deliverables is summarized in Attachment C. All data will be submitted to the Corps in the pre-tested DAIS format. The Corps will convert the DAIS data to SEDQUAL format and transfer to Ecology. Any QA problems (i.e., calibrations, internal standards) must be noted in the laboratory report narrative. Chemical data will be qualified in accordance with PSEP guidelines. The "J" qualifier will be applied to all concentrations that fall between the limit of detection and the laboratory's method detection limit (MDL). Dilution volumes, sample sizes, percent moisture, and surrogate recoveries will be presented on each summary sheet with the analytical results in the data packages. Similar information will also be assembled for each QC sample (method blanks, matrix spikes, etc.).

4.3 Data Validation

Within 14 days of receipt of the analytical results, the contractor will review all raw data to verify the laboratory has supplied the required QA/QC deliverables. The data will then be validated against QA1 and project criteria for inclusion into the sediment characterization reports.

All analytical results will be validated in accordance with PSDDA QA1 review (PTI, 1989). The QA1 review will evaluate the data for completeness, format, holding conditions, and laboratory QA sample results (e.g., blanks, matrix spikes). The data validation will also include a review of surrogate recovery values for each of the organic samples. Data validation checklists will be followed.

Where data fail criteria provided in the QA1 manual, the laboratory will be contacted, and the data will be: (1) reanalyzed, (2) qualified, or (3) discarded. Data quality issues will be summarized in a data validation report.

5 Biological Testing

Bioassays will be conducted to determine whether chemicals of concern (COCs) outlined by PSDDA are present and bioavailable at concentrations that are toxic to biota. A tiered testing approach will be used. Bioassay procedures used in this program will be conducted in accordance with protocols recommended by PSEP (PSEP, 1995), in addition to standard laboratory procedures. Analyses will be required to conform to accepted standard methods and rigorous internal QA/QC checks prior to final approval. Vizon Scitec, an Ecology-accredited laboratory in Vancouver, B.C., will conduct the biological testing.

5.1 Bioassay Testing Approach

Biological testing will be undertaken on any composite sample which has one or more chemicals of concern above the PSDDA screening level (SL) but below the PSDDA maximum level (ML), although a sample with a single ML exceedance which is less than or equal to two times the ML still qualifies for biological testing. If any COC exceeds a bioaccumulation trigger (BT), a decision will be made as to whether or not to pursue biological testing, which would include the standard suite of PSDDA bioassays plus bioaccumulation testing with Macoma and an adult polychaete (*Nereis virens*, *Arenicola marina*, or *Nepthys caecoides*). If bioaccumulation testing is performed, the organisms and exposure durations will be coordinated with the DMMP.

Adequate sample volume will be collected in the field for chemical, physical, and bioassay/bioaccumulation testing. To the extent practicable, chemical results will be provided for bioassay decisions within 28 days of the first sample collection.

5.2 Sample Handling

Bioassay samples will be composited, placed in appropriate glass or plastic jars with minimal headspace, labeled, and stored on ice in insulated coolers while in the field; all under proper chain of custody procedures. Samples retained for biological analysis will be split from the same composited sample designated for chemical analysis. Table 3-3 specifies the sample jars and maximum allowable holding times for bioassay samples. Following the completion of each day's sample collection, chain of custody forms will be completed for each set of samples.

Sediment samples collected for bioassay analyses will be delivered to the biological laboratory at the end of the sampling period. All samples delivered to the laboratory will be properly packed in coolers and maintained at 4 ºC. Original chain of custody forms and analysis request forms will accompany the samples to the laboratory. All bioassay analyses, including retests, will commence within 56 days after collection of the first core section of the sediment composite to be analyzed. No field duplicates will be submitted for biological testing.

5.3 Sediment Toxicity Tests

The suite of biological tests is summarized in Table 5-1 and will consist of the following tests:

- Acute 10-day Amphipod Mortality (*Eohaustorius estuarius*, *Rhepoxynius abronius* or *Ampelisca abdita*);
- Acute 48-hour Larval Mortality/Abnormality (*Dendraster excentricus*, or *Mytilus* (*edulis*) *galloprovincialis*); and
- Chronic 20-day Juvenile Polychaete (*Neanthes arenoceodentata*).

The final selection of bioassay species will be approved by the PSDDA agencies. Some of the bioassay species show a sensitivity to high percentages of fine grained sediments. Some of the historic sediment samples located near the proposed coring locations contain large proportions of fines. It is possible some samples will contain more than 30% clay. Bioassay tests performed on sediment collected from cores with high clay content must use bioassay organisms that are insensitive to high fines content.

Other historical data collected from stations contained in the site DMMUs tend to be silty sand. If sediment conditions have not changed, bioassay tests performed on sediment collected from cores containing silty sand may use bioassay organisms that are not sensitive to sediments with high percentages of fines.

5.3.1 Species Selection

Amphipod Test

The amphipod *Rhepoxynius abronius* has demonstrated sensitivity to high percent fines in sediments, particularly high clay content sediments, and has exhibited mortalities greater than 20 percent in clean, reference area sediments (DeWitt et al., 1988; Fox, 1993). *Eohaustorius estuaries* has also exhibited sensitivity to high clay content (>30%) despite being relatively insensitive to salinity changes and other effects of grain size. *E. estuarius* will be the preferred amphipod species unless clays are greater than 30 percent clay. *A. abdita* is relatively insensitive to grain size up to concentrations of fines greater than 60 percent (USACE, 2000). If clay is greater than 30% and fines are greater than 60 percent, *A. abdita* will be the preferred amphipod test species. If clay is more than 30% and fines are less than 60%, *R. abronius* will be used for testing. Table 5-1 summarizes the preferred bioassay test organisms for each DMMU composite sample.

Larval Test

For the sediment larval test, adults must be collected in spawning condition or must be induced to spawn in the laboratory. Therefore, seasonality plays a role in selecting a test organism. The preferred species for larval testing is the sand dollar *Dendraster excentricus*. According to the Users Manual for the PSDDA program, *D. excentricus* spawns naturally in Puget Sound from April through December. Larvae of *D. excentricus* do not show an adverse response to increasing silt and clay fractions, and under conditions of expected high silts and clay, the sand dollar test is preferable (EPA, 1993). The bioassay laboratory has had success inducing spawning in *D. excentricus*, however, if spawning is unable to be induced, another species deemed acceptable for test sediments containing at least 60% fines is *Mytilus* (*edulis*) *galloprovincialis*. Although they spawn naturally in Puget Sound between March and July, (USACE, 2000), AMEC bioassay laboratory has had success inducing spawning in *M. galloprovincialis*. Table 5-1 indicates preferred larval bioassay test organism for each DMMU sample.

Prior to initiating bioassay testing, sediment grain size and interstitial salinity will be determined to confirm selection of the appropriate test species. If there is headspace in the jars, nitrogen will be added prior to storage (PSEP, 1995).

5.3.2 Procedures

Amphipod Bioassay

This test involves exposing the amphipod *Rhepoxynius abronius* to test sediment for ten (10) days and counting the surviving animals at the end of the exposure period. Daily emergence data and the number of amphipods failing to rebury at the end of the test will be recorded as well. Amphipod mortality must meet the performance requirements defined in Table 5-2.

Sediment Larval Bioassay

This test monitors larval development of a suitable echinoderm or bivalve species in the presence of test sediment. The test is run until the appropriate stage of development is achieved in a sacrificial seawater control (PSDDA MPR-Phase II, pp. 5-20). At the end of the test, larvae from each test sediment exposure are examined to quantify abnormality and mortality.

Performance standards of the larval test are defined in Table 5-2. Initial counts will be made for a minimum of five 10-ml aliquots. Final counts for seawater control, reference sediment and test sediment will be made on 10-ml aliquots. The sediment larval bioassay has a variable endpoint (not necessarily 48 hours) that is determined by the developmental stage of organisms in a sacrificial seawater control (PSDDA MPR Phase II, page 5-20).

Ammonia and sulfides toxicity may interfere with test results for this bioassay. Aeration will be conducted throughout the test to minimize these effects.

Neanthes Growth Test

This test utilizes the polychaete *Neanthes arenaceodentata*, in a 20-day growth test. The growth rate of organisms exposed to test sediments is compared to the growth rate of organisms exposed to a reference sediment. Performance requirements for this test are defined in Table 5-2.

5.3.3 Negative Controls

Negative control sediments are used in the amphipod and Neanthes bioassays to check laboratory performance. Negative control sediments are clean sediments in which the test organism normally lives and which are expected to produce low mortality. The sediment larval test utilizes a negative seawater control rather than a control sediment. The negative control to be used for the sediment toxicity test will be a clean control (i.e., inert material with site seawater) or native sediment where the organisms reside. Bioassay performance standards for negative controls are identified on Table 5-2.

5.3.4 Reference Sediment

Reference sediments will also be included with each bioassay. Reference sediments provide toxicity data that can be used to separate toxicant effects from unrelated effects, such as those of sediment grain size and total organic carbon. Bioassay testing requires that test sediments be matched and tested simultaneously with an appropriate PSDDA-approved reference sediment to factor out sediment grain size effects on bioassay organisms.

One or two reference samples will be collected from Samish Bay or a similar reference site in Washington if substantially different grain sizes are encountered in the DMMU composite samples. Reference sediments will be collected using a 0.1-square-meter stainless van Veen grab sampler deployed by boat. Upon reaching the designated reference sediment location, a test grab sample will be collected and a subsample will be wet-sieved to determine grain size. If the grain size is not appropriate, the vessel position will be adjusted and another test grab will be collected. This procedure will be conducted until sediments with the proper grain size have been located. Multiple grab samples will then be taken until enough reference sediment is collected. A subsample of the final composite will be wet-sieved to verify the appropriate grain size.

Locations of reference station coordinates will be reported, with an accuracy of ± 3 meters. Reference sediment samples will also be tested for total solids, total volatile solids, total organic carbon, grain size, ammonia, and sulfides. Performance standards for bioassay testing with reference sediment are listed in Table 5-2.

5.3.5 Replication

Five laboratory replicates of test sediments, reference sediments, and negative controls will be run for each bioassay.

5.3.6 Positive Controls

A positive control will be run for each bioassay. The positive control to be used for the sediment toxicity test will be a toxic control in which a reference toxicant is used to establish the relative sensitivity of the test organism. Cadmium chloride will be the positive control reference toxicant used for the amphipod and juvenile polychaete bioassays. Copper sulfate will be the positive control reference toxicant used for the bivalve larvae bioassay. In addition, a water-only ammonia reference toxicant using measured ammonia concentrations will be used for the bivalve larvae bioassay, and a 10-day ammonia-spiked sediment test will be used as a positive control for the amphipod bioassay.

5.3.7 Water Quality Monitoring

Bioassays require that proper water quality conditions be maintained to ensure survival of the organisms, and to ensure that undue stress is not exerted on the organisms unrelated to test sediments. Daily water quality measurements include salinity, temperature, pH, and dissolved oxygen for the amphipod and sediment larval tests. These measurements will be made every three days for the *Neanthes* bioassay. Ammonia and total sulfide concentrations in both porewater and overlying water will be measured at test initiation and termination for all three tests. Monitoring will be conducted for all test and reference sediments and negative controls (including seawater controls).

For the amphipod test, according to DMMP guidance implemented in the 2002 clarification paper (EPA, 2002), coordination with the DMMO should occur prior to testing regarding the need for purging if interstitial ammonia concentrations approach 30 mg/L total ammonia for *A. abdita* or *R. abronius* testing. If a value of one half of the threshold value for purging (15 mg/L total ammonia) for either amphipod species test is exceeded, an ammonia reference toxicant test (LC50) test must be performed to assist with test interpretation. Purging methods will follow that listed in the DMMP clarification paper (EPA, 2002), and ammonia will be reported for initial bulk sediment interstitial ammonia, total and unionized ammonia at test initiation (day 0) and day 10, overlying water ammonia should be reported as part of the regular daily water quality measurements, and LC50 water only experiment data should be reported.

Parameter measurements must be within the limits specified for each bioassay. Interstitial salinity will be documented at test initiation for the amphipod bioassay. Measurements for each treatment will be made on a separate chemistry beaker set up to be identical to the other replicates within the treatment group, including the addition of test organisms.

5.4 Interpretation

Test interpretations consist of endpoint comparisons to controls and reference on an absolute percentage basis as well as statistical comparison to reference. Test interpretation will follow the guidelines established in the PSDDA Management Plan Report — Phase II and the minutes of the dredging year 1991 annual review meeting for the *Neanthes* bioassay, as modified by subsequent annual review proceedings and workshops. Current endpoints are those provided in the PSDDA Users Manual (February, 2000), which are reproduced in Table 5-2 as they pertain to the non-dispersive disposal sites.

5.5 Bioaccumulation Testing

Bioaccumulation testing will be performed if any COC exceeds a bioaccumulation trigger (BT). An adult bivalve (*Macoma nasuta*) and an adult polychaete (*Nereis virens*, *Arenicola marina*, or *Nephtys caecoides*) will be used for bioaccumulation testing. Test organisms and exposure periods will be coordinated with the DMMP prior to testing.

5.6 Laboratory Reporting Requirements

A written report will be prepared by the biological laboratory documenting the activities associated with the samples. The laboratory will be responsible for internal checks on data reporting and will correct errors identified during the quality assurance review. Bioassay laboratories must meet the DMMP QA2 deliverable requirements so that data may be incorporated into the SEDQUAL database. A list of QA2 deliverables is summarized in Attachment C. Elements of the report will include:

- A discussion of any deviations from methodology or problems with the process and procedures of analyses;

- Test methods used for bioassay testing and statistical analyses;

- Sources and collection locations of all bioassay organisms;
- Results for survival, growth, reburial, abnormalities, water quality parameters, reference toxicant, and statistical analyses;
- Original data sheets for water quality, survival, growth, reburial, abnormalities, reference toxicant, and statistics;
- Original quality control checklists;
- Custody records; and
- Results of the laboratory bioassay analyses and QA/QC results, reported both in hard copy and in the USACE Dredged Analysis Information System (DAIS) data format. Raw data will be legibly written or typed. If data are unintelligible and cannot be interpreted by the DMMP agencies, a retest may be required.

6 Reporting and Deliverables

RETEC will document all activities associated with collection, compositing, transportation, and analysis of samples. Data summary results will be presented in tabular form using maps and figures as appropriate. Laboratory analytical results/reports will be included as appendices along with the data validation reports. Results will be presented in a final report and discussed relative to the objectives of this sediment sampling effort. The results section will include, at a minimum, a discussion of the following issues:

- **Sample Collection and General Observations**
  - Type of sampling equipment used;
  - Protocols and procedures used during sampling and testing and an explanation of any deviations from the sampling plan protocols;
  - Descriptions and core logs of each sample, including penetration and recovery depths, compositing intervals, mudline elevation, grain size, and geologic contacts;
  - Methods used to locate the sampling positions (within an accuracy of ±2 m);
  - Maps and tables identifying locations where the sediment samples were collected, reported in latitude and longitude to the nearest tenth of a second, and in State Plane Coordinates; and
  - A plan view of the project site showing the shoreline, bathymetry, and actual sampling locations.
- **Analytical Testing Results**
  - Chain of custody procedures used, and explanation of any deviations from the sampling plan procedures.
- **Tabular Summary**
  - Tabular summary of chemical (dry weight) and physical data with comparison to SMS and PSDDA criteria. Any PSDDA chemical exceedances will be highlighted and discussed. Trends in contaminant levels will be discussed, if apparent;
  - Biological testing results, with comparisons to PSDDA biological testing criteria. Any failures of PSDDA toxicity and/or bioaccumulation criteria will be highlighted and discussed; and
  - Final QA Report, which will identify any field and laboratory activities that deviated from the approved sampling plan and the referenced protocols. The QA Report will assess the overall validity of the collected data.

7 References

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